

AN EVALUATION OF
PHYTOPLANKTON DATA
LOCH LOMOND WATER SUPPLY
CITY OF THUNDER BAY
1972 - 1988

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AN EVALUATION OF PHYTOPLANKTON DATA

LOCH LOMOND WATER SUPPLY

CITY OF THUNDER BAY

1972 - 1988

Gordon J. Hopkins
Aquatic Plant Unit
Water Resources Branch

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PREFACE

Phytoplankton records showing algal density and taxonomic composition have been maintained at two water supply locations in the City of Thunder Bay for various periods since 1972. The Northwestern Regional Office requested a summary of the available phytoplankton data and associated taste and odour problems from the Loch Lomond water supply.

SUMMARY

The City of Thunder Bay receives water for its municipal supply from two sources: Bare Point, Lake Superior and Loch Lomond. The latter source is unfiltered and receives limited treatment before being distributed to the south ward of the city where numerous taste and odour complaints have been received over the years.

This report summarized phytoplankton records maintained since 1972 showing algal densities and taxonomic composition for 127 quantitative samples collected from the Loch Lomond supply. An additional 38 samples collected from the South Ward distribution system resulting from consumer complaints in regards to tastes and odours were analysed. Taste and odour organisms were a major component in 31 of these samples. While total biomass has been low to moderately high (57-296 A.S.U./mL) throughout this period several algal organisms have been prominent in taste and odour events. Aphanizomenon, Asterionella, Dinobryon and Synura, all taste and odour producing organisms, were responsible for many of these complaints. In 1972-73, seasonal succession was characterized by a decrease in the total biomass of algae with the onset of winter weather, but in 1986 and 1987, Synura petersenii (a known taste and odour producing alga) became abundant with the onset of cold weather and thrived under winter ice causing numerous consumer complaints in the South Ward area of the City of Thunder Bay. Consumer complaints caused by taste and odour type algae will continue to be a problem as long as the Loch Lomond supply remains unfiltered.

INTRODUCTION

The City of Thunder Bay, on the northwest shore of Lake Superior has had an historical record of impaired water quality due to taste and odours related to biological materials in the water supply. Prior to amalgamation in 1970, Port Arthur served the north ward of Thunder Bay drawing water from the intake at Bare Point, Lake Superior while Fort William serviced the South Ward of Thunder Bay by drawing water from an intake located in Loch Lomond. At this time, the treatment process was limited to pumping and chlorination only. The City of Thunder Bay continues to use the two sources of water supply but in 1978 the Bare Point, Lake Superior supply was upgraded to full treatment which included chemically assisted filtration and chlorination. The Loch Lomond supply continues to be pumped to the distribution system unfiltered and receives treatment only in the form of chlorination and sodium silicate to reduce the "aggressiveness" of the water.

Over the years, this Ministry has received numerous consumer complaints from the City of Thunder Bay, almost all of which were associated with tastes and odours in the water. Samples collected from the distribution system and examined in our laboratory invariably contained biological material such as algae, microcrustaceans and organic detritus. It was an accepted fact that the distribution system harboured numerous viable biological organisms, many of which, periodically accumulated in sufficient quantities to impart tastes and odours.

The Ministry of the Environment has recommended that maintenance of the distribution system should include a routine programme of swabbing the mains to remove the accumulations of organic material in the distribution system. A flushing programme is currently in place for the South Ward distribution system. However, consumer complaints related to tastes and odours continue and the causes are primarily related to algal organisms found in the raw water supply, particularly from Loch Lomond. A separate report (Hopkins 1986) has been prepared for algal and chemical conditions related to the Bare Point, Lake Superior supply.

In 1987 a request was received from the Northwestern Regional Office to assess the available phytoplankton data and comment on the levels of nuisance algae in the Loch Lomond supply. Quantitative phytoplankton data are available for the years 1972-73, 1977-78 and 1984-87. In addition we have documented records of twenty occurrences of taste and odour complaints received since 1973, with the most recent ones being received in January 1988.

METHODS

Water quality monitoring at the Thunder Bay water supply intakes is done on a weekly basis throughout the year. One litre samples of raw water collected for phytoplankton analyses are preserved with Lugol's iodine solution, concentrated in the laboratory and stored in 25 mL vials. At the time of analysis a one to five mL aliquot of the sample concentrate is placed in a counting chamber for examination. Prior to 1974, samples from the Thunder Bay water supply were enumerated in a Sedgewick-Rafter counting chamber at 200X magnification. Since 1974, these samples have been examined using a Utermöhl counting chamber at 600X magnification. Measurements of the surface area of the algal taxa are taken and reported as Areal Standard Units per millilitre (A.S.U./mL). One A.S.U. is equal to the area subtended by 400 square microns, (APHA 1985). Aliquots of the weekly samples collected since 1984 have been combined to form monthly composited samples for which results have been reported as monthly mean A.S.U./mL. Therefore individual weekly results from 1972-73 and 1977-78 have been averaged on a monthly basis (Table 1). As there are limited data available for 1977-78, comparisons in this report were made mainly on the 1972-73 results and the 1984-87 results. While quantitative data were not provided for the 37 samples submitted as a result of consumer complaints, the dominant and/or most abundant organisms were identified with a notation on their significance in relation to taste and odours (Table 2).

RESULTS AND DISCUSSION

From May 1972 to December 1973, 67 weekly samples were analyzed. Monthly mean A.S.U./mL values rose throughout the summer of 1972 to a mean of 480 A.S.U./mL in August and then declined to 35 A.S.U./mL by February of 1973. During the summer of 1973 algal biomass again rose to values of 340-450 A.S.U./mL reaching a peak in October when the mean was 652 A.S.U./mL. Values dropped off rapidly in November and December, 1973 with the onset of cold weather.

From January 1984 to the present, samples were combined prior to examination so that 44 composited samples were analyzed to provide the data for this report. From 1984 to 1986 winter minima occurred followed by a spring pulse (April) a summer low and then a return to a late summer or early fall peak (September, 1984 and October 1985/86). In 1984 and 1985 the biomass levels declined rapidly in November and December to reach the low winter means of 18-19 A.S.U./mL. However, from October 1986 to February 1987 the monthly mean algal levels did not decline and consumer complaints were experienced in November 1986 and January 1987. While quantitative data are not available, consumer complaints have also been reported in December 1987 and January 1988 (Table 2).

Since 1972, 127 phytoplankton samples have been analyzed quantitatively from Loch Lomond in which 132 taxa have been identified (Table 3). Forty-eight taxa are known taste and odour type organisms. During 1972-73, 87 taxa were identified in 67 samples of which 29 were taste and odour producing organisms, whereas the 44 samples analyzed between 1984-1987 contained 104 taxa of which 42 were of the taste and odour variety. Eleven organisms (Table 3) capable of producing tastes and/or odours in the water were among the taxa observed as being abundant in 1972-73, while 10 organisms fell into this category in 1984-87.

The diatom, Rhizosolenia was frequently the most abundant organism during the 1972-73 period, however, it is not a known taste and odour organism. Asterionella, another diatom was the most frequent taste and odour alga present in 1972-73 followed by Dinobryon and Synura.

From 1984 to the present there was a decline in the biomass of algae present (Table 2). Tabellaria and Asterionella were frequently the most abundant algae present and both are known taste and odour producing organisms. However, from August 1986 to February 1987 the chrysophytes Synura and Dinobryon were the most abundant organisms present in addition to the above-mentioned diatoms. Again in May and June of 1987 Synura was the most abundant organism present. Analyses have not been completed to the end of 1987 but Synura petersenii was the source of taste and odour complaints recorded for December 1987 and January 1988.

Since 1973 we have analyzed a total of 37 samples collected from the South Ward of the Thunder Bay distribution system. Of these 37 samples, the diatoms Asterionella, Melosira and Tabellaria were identified as being the most abundant algal taxa in 15 samples. Synura and Dinobryon were the source of 13 complaints while the blue-greens Chroococcus and Aphanizomenon were abundant in two distribution system complaint samples.

Asterionella, Tabellaria and Melosira all impart a geranium odour to the water in moderate quantities and a fishy odour when present in abundant quantities. Synura and Dinobryon cause a cucumber and violet odour respectively when present in small quantities and a fishy odour when present in abundant quantities. Chroococcus and Aphanizomenon impart a grassy or musty odour when present in small quantities and this changes to a septic odour when it becomes more abundant.

A look at the quantitative analyses of raw water from Loch Lomond which correspond to the dates when consumer complaints were registered, reveal that on January 30, 1973 Synura (65 A.S.U./mL) was the most abundant alga present whereas diatoms were the most abundant algal taxa found in three distribution system samples. More diatoms may be observed in distribution system samples than other algal forms because the rigid silaceous shells are less susceptible to damage in passing through the system. Taxa such as Synura have delicate cell walls which

readily rupture when they come into contact with chlorine in the treatment process, thus making the organism unidentifiable. In late July, 1973 Dinobryon (129 A.S.U./mL) and Tabellaria (151 A.S.U./mL) were the most abundant algae present in the raw water when a consumer complaint was received.

Synedra (31 A.S.U./mL) and Melosira (14 A.S.U./mL) were the most abundant of 14 genera of diatoms present in raw water samples in May 1984 when a taste and odour complaint was registered. In December 1984 Cryptomonas (42 A.S.U./mL), an alga capable of producing a violet odour was the dominant organism in the monthly raw water composite sample. On February 5, 1985, November 27, 1985 and September 24, 1986 taste and odour complaints were registered by consumers. However, no algae were found in the distribution system samples. Total algal biomass in February, 1985 was only 15 A.S.U./mL. In November, 1985 the algal biomass rose to 98 A.S.U./mL and was dominated by Synura (27 A.S.U./mL) and Tabellaria (25 A.S.U./mL). The September, 1986 raw water sample contained a total of only 6 A.S.U./mL. The raw water counts were dominated by Synura at levels of 270, 147, 166, 438 and 476 A.S.U./mL from October, 1986 to February, 1987, during which time seven distribution system samples were received as a result of consumer complaints.

In May and June, 1987 Synura again rose to nuisance proportions and dominated the raw water counts at 127 and 301 A.S.U./mL. On May 28, 1987, 4 samples were received from the Loch Lomond portion of the distribution system and the diatom Asterionella and the chrysophyte Synura were the most abundant organisms present. The taxa Synura petersenii was confirmed (by electron microscopy) as being present in Loch Lomond in June 1982 and in January 1987. It is the only known species of Synura recorded from Ontario waters that is capable of producing fishy tastes and odours (Nicholls and Gerrath 1985).

From samples submitted on January 8, 1988, Synura was the most abundant organism present in both the raw water and the distribution system samples. At the time of this report quantitative analyses are not available for this time period.

It would appear from the data available in this report that consumer complaints may be registered at levels (measured as A.S.U./mL) much lower than previously suggested (Palmer 1962). The only source known to me for which quantitative data are cited. He stated that algal levels, at which taste and odour control measures need to be taken, vary greatly (3000 A.S.U./mL for Asterionella, 700 A.S.U./mL for Dinobryon and only 200 A.S.U./mL for Synura). These levels are much higher than those experienced in the Loch Lomond supply. This may be due, in part, to a difference in water chemistry. The soft water lakes of northern Ontario where Synura is frequently a source of consumer complaints, may be different from the sources cited by Palmer. As long as this supply remains unfiltered, tastes and odours caused by algal organisms will continue to be a source of consumer complaints.

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Table 1: Phytoplankton biomass in Loch Lomond raw water supply, Thunder Bay, Ontario between 1972 and 1987. All values expressed as Areal Standard Units per millilitre.

Year	1972	1973	1977	1978	1984	1985	1986	1987
	Monthly Average				Monthly Composite			
Month:								
January	-	85	-	-	38	19	18	457
February	-	35	-	-	33	15	127	492
March	-	100	-	40	22	33	35	52
April	-	132	-	96	63	124	88	89
May	109	105	99	77	6	56	227	
June	416	365	179	-	144	28	448	395
July	363	340	-	-	57	4	85	-
August	480	250	-	-	105	3	256	53
September	329	450	-	-	172	108	6	85
October	214	652	-	-	115	125	522	-
November	161	213	-	-	72	98	250	-
December	-	123	-	-	75	38	225	-
Annual Mean	296	238	-	-	81	57	176	(231)

Table 2: Complaint samples received from City of Thunder Bay distribution system serviced by Loch Lomond water supply, 1973-1988.

Date	Location	Quantity A.S.U./mL	Dominant Taxa	No. of taxa identified	No. of taste and odour taxa
30/01/73	Loch Lomond	85	Synura	9	6
"	Drew School	38	Diatoms	16	12
"	Gray Park School	48	Diatoms	17	9
27/07/73	451 Broadway	4	-	7	4
17/09/76	319 Cameron Street (hot H ₂ O)	-	-	13	4
"	" (cold H ₂ O)	-	Chroococcus	16	8
30/11/77	MOE Lab. tap	-	Melosira	38	16
20/07/78	448 Heather Crescent	87	-	26	9
04/01/82	742 Norah Street	-	Melosira	29	13
29/06/82	Loch Lomond - raw	-	Dinobryon, Synura petersenii	27	13
15/12/82	Airplane Motel	78	Diatoms	26	15
28/01/83	396 Empire Street	-	Asterionella	10	5
22/07/83	Loch Lomond intake	-	Unidentified	-	-
16/09/83	641 S. Edward Street	10	-	27	18
15/09/83	138 Mark Street	62	Diatoms	23	15
"	"	76	"	22	15
23/05/84	380 Empire Street	-	"	16	8
07/12/84	S. Ward distribution	-	Iron bacteria	12	6
05/02/85	611 Hargrave	-	-----No biological material identified-----		
27/11/85	110 Empire Street	-	None	6	-
24/09/86	1285 Regina Street	-	No algae	-	-
21/11/86	Northern Bev. - raw	-	Asterionella, Synura	11	9
"	" - after filters	-	" "	13	10
"	" - treated	-	No algae	-	-
02/01/87	Loch Lomond - treated	-	Synura petersenii	15	13
"	213 Gore Street	-	" "	18	14
"	434 E. Christina	-	" "	13	11
"	301 W. Christina	-	" "	7	7
"	Loch Lomond intake screen	-	F.W. Bryozoa	18	9
28/05/87	226 Syndicate Street	-	Asterionella	8	6
"	Loch Lomond intake screen	-	Asterionella, Synura	15	12
"	Reservoir - tap	-	" "	10	8
"	Loch Lomond - surface scum	-	Bryozoa statoblasts	11	5
22/12/87	Loch Lomond - raw	-	19	10	-
"	226 S. Syndicate	-	Synura	18	8
23/12/87	1311 E. Victoria	-	"	11	7
08/01/88	328 Piper Street	-	Synura, Aphanizomenon	7	5
"	449 Frontenac Avenue	-	" "	12	9

Table 3: Algal taxa (by class) observed in Loch Lomond water supply, Thunder Bay, Ontario, 1972-73 and 1984 to 1987. Taste and odour types designated with an asterisk (*).

Species	72-73	84-87	Species	72-73	84-87	Species	72-73	84-87
<u>Bacillariophyceae</u>			<u>Chrysophyceae</u>			<u>Cyanophyceae</u>		
Rhizosolenia	1st	P	Dinobryon*	1st	2nd	Oscillatoria*	1st	P
Asterionella*	2nd	1st	Synura*	2nd	1st	Gomphosphaeria*	2nd	P
Cyclotella*	3rd	P	Unknown chrysophyte	3rd	3rd	Chroococcus*	3rd	P
Tabellaria*	4th	2nd	Mallomonas*	P	P	Coelosphaerium*		1st
Synedra*	P	3rd	Ochromonas	P	P	Lyngbya	P	2nd
Melosira*	P	P	Chrysosphaerella*	P		Anabaena*	P	3rd
Nitzschia	P	P	Chrysochromulina	P	P	Aphanizomenon*	P	4th
Stephanodiscus*	P	P	Salpingoeca	P	P	Merismopedia	P	P
Cymbella	P	P	Dinobryon bavarisum*		P	Aphanothece	P	P
Amphiprora	P	P	D. divergens*		P	Rhabdoderma	P	P
Achnanthes	P	P	D. epiphytica*		P	Microcystis*	P	P
Eunotia	P	P	D. sertularia*		P	Unident. B-G	P	P
Epithemia	P	P	Spiniferomonas		P	Aphanocapsa	P	
Cyclotella glomerata	P		Kephyrion		P	Dactylococcopsis	P	
Surinella	P		Chromulina		P	Calothrix	P	
Navicula	P		Epipyxis		P	G. aponina		P
Pinnularia	P		Diceras		P	Chroococcus limneticus		P
Gyrosigma	P		Monochrysis		P	Lyngbya limnetica		P
Fragilaria*	P		Uroglena americana*		P			
Attheya	P		Mallomonas akrokomas*		P	18 taxa/ 7 T & O.	14/6	15/7
Asterionella formosa*		P	Salpingoeca siderotheca		P			
Tabellaria fenestrata*		P	Unknown (banana) chryso.		P	<u>Dinophyceae</u>		
Fragilaria crotonensis*		P	Chrysochromulina parva		P	Peridinium*	1st	
Cymatopleura		P	Chrysococcus		P	Gymnodinium	P	P
Fragilaria capucina		P	Chrysolykos		P	Ceratium*	P	
Diatoma*		P	Chromulina erkensis		P	P. pusillum*		P
Synedra ulna*		P	Chrysosphaerella solitaire*		P	P. cinctum*		P
			Bitritchia		P	P. limbatum*		P
27 taxa/12 taste& odour* 20/7*		20/11*	Synura petersenii*		P	Unident. dino.		P
						Unident. armoured		P
<u>Euglenophyceae</u>			29 taxa/12 T & O.	8/4	28/11			
Euglena*	P	P				8 taxa/5 T & O.	3/2	6/4
Trachelomonas	P		<u>Cryptophyceae</u>					
Lepocinclis		P	Rhodomonas	1st	1st			
			Cryptomonas*	2nd	2nd			
3 taxa/1 T & O.	2/1	2/1	Katablepharis	P	P			
			3 taxa/1 T & O.	3/1	3/1			

Table 3: Cont'd.....

Species	72-73	84-87		72-73	84-87
<u>Chlorophyceae</u>					
Scenedesmus*	1st	P	Staurodesmus	P	P
Ankistrodesmus = Monoraphidium	2nd	P	Gyromitus	P	P
Chlamydomonas*	P	P	Chlorogonium	P	
Oocystis	P	P	Carteria	P	
Coelastrum	P	P	Mougeotia	P	
Crucigenia	P	P	Selenastrum	P	
Botryococcus	P	P	Closteriopsis	P	
Elakatothrix	P	P	Staurastrum*	P	
Quadrigula	P	P	Gloeocystis*	P	
Sphaerocystis	P	P	Lagerheimia	P	
Spondylosium	P	P	Golenkinia	P	
Nephrocytium	P	P	Closterium*	P	
Cosmarium*	P	P	Planktosphaeria	P	
Tetraedron	P	P	Pedinomonas	P	
Euastrum	P	P	Micractinium	P	
Dictyosphaerium*	P	P	Unident. colony	P	
Arthrodesmus	P	P	Pediastrum*		P
Schroederia	P	P	Paramastix		P
Tetradesmus	P	P	Gemellicystis		P
Pandorina*	P	P	Isthmochloron		P
Nephrochlamys	P	P	Unident. filament		P
			Eudorina*		P
43 taxa/10 taste & odour	37/8	29/7			